Third United Nations International Conference on the Peaceful Uses of Atomic Energy

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Abstract

A DIFFUSION MECHANISM OF RELEASE OF FISSION GASES IN REACTORS

K.G.Vohra and V.S.Bhatnagar
Atomic Energy Establishment Trombay

During the normal operation of the reactors using different types of fuel elements fission gases are released in the coolant in immediate contact with the fuel elements by the mechanism of gas metal diffusion. Experiments carried out for the estimation of the fraction of fission gases released into the coolant in a swimming pool reactor have provided valuable information on the above mechanism.

Measurements of fission gases and their daughter products in the coolant and in the atmospheric air in a swimming pool reactor have established the proposed mechanism of diffusion in which the degree of release of fission gases would depend on the nature and composition of the fuel, its temperature and surface area, the geometry of the fuel element and the coefficient of diffusion. The proposed model can be used for the calculation of release of fission gases in reactors of different types under normal operation.

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Abstract

DESIGN OF AN ELECTROSTATIC PRECIPITATOR MONITORING SYSTEM FOR RUPTURED FUEL ELEMENT DETECTION

B.S. Prabhakar, R. Sethuraman, K. Srinivasan and K. Venkatachalam
Atomic Energy Establishment Trombay

The performance of an "Electrostatic Precipitator Monitor" for the detection of ruptured fuel elements was studied simulating the conditions of rupture at Apsara Reactor with air and CO_2 as carrier gases. Optimisation of parameters is indicated and design methods are discussed. Calculations were performed to determine the efficiency of the system taking into consideration the relevant fission product chains. Agreement between theoretical and experimental results is shown. The design was modified for water carrier system using air as scrubber gas. A monitor based on this design is being installed at Apsara Reactor.

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Abstract

GAMMA ENERGY RELEASE RATES FROM FISSION PRODUCTS AT SHORT TIMES OF COOLING

M.Ramakrishna Iyer and A.K.Ganguly
Atomic Energy Establishment Trombay

In the present paper the gamma energy release rates and photon emission rates from fission product mixture formed from the instantaneous fission of uranium-235 have been computed. The data on fission yields, half-lives and gamma decay energies have been taken from our latest compilation (complete upto June 1962) of the nuclear properties of uranium-235 fission products. The gamma spectrum is presented by dividing the fission product gamma energies into ten groups on the basis of their weighted average energies and weighted average air dose characteristics. The variation of gamma energy release rates, photon emission rates and weighted average energy in each group and in the total fission products have been studied. The results are plotted for decay times ranging from 10^{-1} to 10^{5} seconds. The gamma energy release rates presented in this paper are found to be a significant improvement over the existing computed values at cooling times less than 1000 seconds. Above 1000 seconds the values agree with the computed values obtained by earlier workers.

A new experimental technique has been developed to estimate the time dependance of gamma energy release rates at times of cooling in the region of milli-seconds and onwards. The decay of the gammas starting from this time region has been followed by taking the fast movie photos of the scalers counting the photons from fission products has been adopted for converting the results obtained for finite irradiation to the case of instantaneous fission. The experimental curve of count rate versus time is slightly steeper than the experimental curve of Fermi and King and is more or less in agreement with the slope of the total energy curve of Way and Wigner. Carver's speculation on the gamma energy release rate in the time region of fraction of a second after fission gives a steeper slope than the results obtained in the present experiment.

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PRIMARY COOLING WATER SYSTEM CHARACTERISTICS UNDER TRANSIENT CONDITIONS IN CIR

G.G. Joshi, M. Sampathkumaran, S. Srinivasan
and
V. Surya Rao
Atomic Energy Establishment Trombay

The primary cooling water system of CIR is designed for recirculation with a normal flow rate of 4200 IGPM. Any shut down of the primary pumps results in a reactor scram, whereby recirculation is converted to a one-pass gravity feed emergency system with a flow rate of 1200 IGPM achieved in 8 seconds. The transition period between normal recirculation and full emergency flow condition is most important in hazards evaluation since during this period the flow and power coast down should be ensured to provide sufficient cooling to prevent fuel failure.

During commissioning period, a number of tests were conducted to determine system flow and pressure behaviour in the change-over period from normal recirculation to a one-pass system. The experimental flow coast down data were in general agreement with the predicted hydrodynamic characteristics of the system, though flow and pressure oscillations were observed. A computer programme was detailed to calculate the aluminium cladding and bulk coolant temperatures (in the change-over period) along the length of fuel rod, using theoretical flow coast down and power decay data. The computer was also programmed to estimate coolant saturation temperatures and to detect any boiling under the conditions. When the flow and pressure oscillations that were observed in the commissioning tests were super-imposed on the computer results, the uncertainty was so great that unsafe conditions of nucleate and/or bulk boiling appeared possible. Pending further investigations,

reactor power was limited to 30 MW and the rod output to 300 kW.

Several modifications to the cooling system for improved flow rates and pressures during change-over period were considered. Flow coast down tests were repeated to assess reproducibility of earlier results. At the same time, experimental measurements of coolant temperature transients at fuel rod exit were made under intermediate reactor power operating conditions to assess accuracy of computer predictions. No pressure and flow oscillations were observed during these and subsequent flow coast down tests. Observed temperatures being consistently much lower than predicted values, it was clear that there was no risk of the aluminium cladding of the fuel rod melting or the phase transition temperature for uranium being reached. Nevertheless, the observed temperatures indicated nucleate boiling for 40 MW operation. It was thus concluded that reactor operation at 40 MW called for certain modifications to the primary cooling system. Improvement in the hydrodynamic characteristics of the system was effected by installing fly-wheels on each of the primary coolant pumps, and flow coast down tests repeated. A computer programme with this data indicated the absence of boiling of any kind in fuel rods for a reactor power with individual fuel rod output not exceeding 330 kW. Only slight nucleate boiling was observed at fuel rod outputs of 375 kW. Further experimental measurements of temperature transients for cladding and exit water indicated little or no rise from normal equilibrium values for fuel rods under high power operating conditions, during the change-over period following pump shut down. As experimental values and computer analysis firmly established that there were no hazards involved in operating the reactor at high power, the reactor power was raised to the full design value of 40 MW and operated satisfactorily.

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Abstract

MANAGEMENT OF RADIOACTIVE WASTES AT TROMBAY

R.V. Amalraj, A.R. Chinoy, J.D. Sehgal and K.T. Thomas

Atomic Energy Establishment Trombay

The Atomic Energy Establishment Trombay houses both industrial and research set-ups including such diverse facilities as production units for uranium, thorium and plutonium, fuel element fabrication shop, laboratories and research reactors. The radioactive wastes produced from such a centre will vary widely over a spectrum of activity levels and chemical nature. In this paper the magnitude of the problem is presented and the manner in which it has been solved or is proposed to be solved is dealth with.

The paper stresses the strict limits put on the discharge of radioactivity at Trombay due to the low water renewal rate of Bombay Harbour Bay, the existence of fishing and salt production industries dependent on the bay waters, the nearness of the centre to the City of Bombay and the high water table and heavy monsoon rains in the area.

Various factors were considered for evolving a suitable waste management philosophy at Trombay. Details of these considerations and short descriptions of existing and proposed waste treatment plants and facilities including methods of handling radioactive sludges and management of high level wastes from the fuel reprocessing plant are given.

Research work being carried out for improvement of present techniques and development of new methods of treatment and disposal is summarised.

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Abstract

SOLID STATE NUCLEAR SAFETY SYSTEM

L. Conti and M. Conti
Divisione Tecnologica, Comitato Nazionale per l'Energia Nucleare (CNEN), Casaccia, Roma, Italia

Within the framework of its nuclear reactor development programme CNEN is carrying out a research and development scheme on nuclear reactor control equipment, known as the SCIN Programme. Under this project the Servomechanism Laboratory has developed a fairly complete set of solid state nuclear instrumentation devices.

In a general safety system we can identify:

1. alarm situation detectors (safety amplifiers, radioactivity monitors, pressure and temperature trips, etc.);
2. a logical network which works out the various alarm signals (as for instance two of three circuits, interlock circuits, etc.);
3. the magnet switch power amplifier, which supplies the direct current needed for energizing the scram (magnets or clutches) or set-back mechanism.

In our system all the alarm signals are under the form of voltage; in other words, under normal conditions the voltage is + 5V, while under alarm conditions the voltage is zero.

In this way, any possible disconnection in the alarm channels would produce a safe action. All 5V signals are electronically generated by trip detectors.

1. In the sector of alarm situation detectors we have worked out an electrometer amplifier (10^{-10} + 3.10^{-4}A f.s.) and a shut-down amplifier (10^{-6} + 10^{-4} A continuously adjustable) which employ a new continuous check method.

In both devices a 15 000 Hz check signal is superimposed to the high voltage for the compensated ionization chambers. This signal spreads through the cables and chamber capacitance, up to the d.c. feedback stabilized amplifier, at the output of which there is connected a pass-band amplifier which further intensifies the check signal. Finally, this signal is rectified into a 5 V d.c. voltage.

Thus, a failure in the whole channel (H.V. power supply cable connection, d.c. amplifier) prevents the signal from travelling further and the voltage falls from 5 to zero.

2. The logical network developed by CNEN receives the various alarm signals and provokes the actuating and warning signals, all of which are under the form of 5V-0V. The most attractive features of this unit are its fail-safe characteristic and the possibility of synthetizing any logical function, starting from the fundamental AND, OR and NOT building blocks. The fail-safe feature is obtained through a pulse modulation system.

   A fourth logical block, the RAD, is a completely fail-safe pulse-d.c. converter, required for generating the actuating or warning signals and, normally, low power d.c. signals.

3. In order to feed the actuator electromechanism, we have built two types of completely fail-safe pulse-d.c. power amplifiers. Both are basically pulse-driven d.c. - d.c. converters.

   This configuration is suitable for avoiding any unsafe failure that may occur when using solid state d.c. switching devices.

   The first amplifier can supply up to 100 W and its final stage is transistorized. The second one can supply up to 5 kW, at an efficiency of about 90% and uses silicon-controlled rectifiers.

   In the logical and power units some degree of redundancy can be employed, in order to improve the efficiency of the whole system. This same method has been used in the ROSPO organic critical facility, which achieved criticality on June 10, 1963.